Agilent
PSA Series Spectrum Analyzers
Self-Guided Demonstration for
GSM and EDGE Measurements

Product Note

This demonstration guide is a tool to help you gain familiarity with the basic functions and important features of the Agilent PSA series spectrum analyzers. Because the PSA series offers expansive functionality, the demonstration guide is available in several pieces. This portion introduces the advanced, one-button power measurements and digital

demodulation capability of the GSM with EDGE Measurement Personality (Option 202). All portions of the self-guided demonstration are listed in the product literature section at the end of this guide and can also be found at

http://www.agilent.com/find/psa

All exercises in this demonstration utilize the E4438C vector signal generator. Keystrokes surrounded by [ ] indicate *hard* keys located on the front panel, while key names surrounded by { } indicate *soft* keys located on the right edge of the display.

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About the PSA series

The Agilent PSA series is a family of modern, high-performance spectrum analyzers with digital demodulation and one-button measurement personalities for 2G/3G applications. It offers an exceptional combination of dynamic range, accuracy, and measurement speed. The PSA delivers the highest level of measurement performance available in Agilent spectrum analyzers. An all-digital IF section includes fast Fourier transform (FFT) analysis and a digital implementation of a swept IF. The digital IF and innovative analog design provide much higher measurement accuracy and improved dynamic range compared to traditional spectrum analyzers. This performance is combined with measurement speed typically 2 to 50 times faster than spectrum analyzers using analog IF filters.

The PSA series complements Agilent's other spectrum analyzers such as the ESA series, a family of mid-performance analyzers that cover a variety of RF and microwave frequency ranges while offering a great combination of features, performance, and value.

Part 1
Demo preparation

The following options are required for the ESG and the PSA series.

Product type	Model number	Required options
ESG vector signal generator	E4438C	001 or 002 – baseband generator 402 – TDMA personalities
PSA series spectrum analyzer	E4440A/E4443A/E4445A/ E4446A/E4448A	B7J – Digital demodulation hardware 202 – GSM with EDGE measurement personality

The Global System for Mobile Communications (GSM) digital cellular standard is a time division multiple access (TDMA) multiplexing scheme that uses Gaussian minimum shift keying (GMSK) modulation. Making GSM measurements and meeting standards requirements presents unique challenges. Enhanced Data Rates for GSM Evolution (EDGE), which is also TDMA but uses $3\pi/8$ 8PSK (phase shift keying) modulation, is an enhancement to GSM that promises to deliver true third-generation (3G) wireless services such as multimedia and other broadband applications. Since many essential EDGE transmitter measurements are similar to GSM measurements, the greater part of this guide addresses GSM measurements. The last part concentrates on the EDGE measurements, particularly where they are different from GSM. The PSA series with this optional measurement personality can make complex GSM and EDGE measurements easy.

Begin by connecting the ESG's 50 Ω RF output to the PSA's 50 Ω RF input with a 50 Ω RF cable. Turn on the power in both instruments. *For multi-slot measurements, the PSA will need an external trigger signal from the ESG.* Connect the "EVENT 1" output on the rear panel of the ESG to the "TRIGGER IN" input on the rear panel of the PSA with a 50 Ω BNC connector cable.

Instructions	Keystrokes
On the ESG:	
Choose GSM 900 frequency band.	[Preset] [Frequency] {More} {Freq Channels} {Channel Band} {GSM/Edge Bands} {P-GSM Base} {Freq Channels On}
Select GSM mode and data format.	{Mode} {Real Time TDMA} {GSM} {Data Format Framed}
Turn on GSM modulation.	{GSM On}
Set the amplitude to -10 dBm.	[Amplitude] [-10] {dBm}
Turn on RF output.	[RF On]
On the PSA:	
Perform factory preset.	[System] {Power On/Preset} {Preset Type} {Factory}
Enter the GSM with EDGE mode in the analyzer.	[Preset] [Mode] {GSM (w/EDGE)}
Verify setup for GSM 900 band.	[Mode Setup] {Radio} {Band} {P-GSM}
Set center frequency to absolute RF channel number (ARFCN*) 1 (935.2 MHz).	[FREQUENCY] {ARFCN} [1] [Enter]

* Absolute radio frequency channel number

Part 2
Transmit power

Carrier power is the measure of in-channel power for GSM systems. Mobile devices and base stations must transmit enough power with sufficient modulation accuracy to maintain a call of acceptable quality without the power leaking into other frequency channels or timeslots. GSM systems use dynamic power control to ensure that each link is maintained with minimum power. This gives two fundamental benefits: overall system interference is kept to a minimum and, in the case of mobile stations, battery life is maximized.

In this section, measure the mean transmitter carrier power and view the signal with high dynamic range.

Instructions	Keystrokes
On the PSA:	
Measure transmit power (figure 1).	[MEASURE] {Transmit Pwr}
Move the threshold level to -40 dB. Notice the horizontal, white level bar move down.	[Meas Setup] {Threshold Lvl} [-40] {dB}

Figure 1.
Transmit power measurement
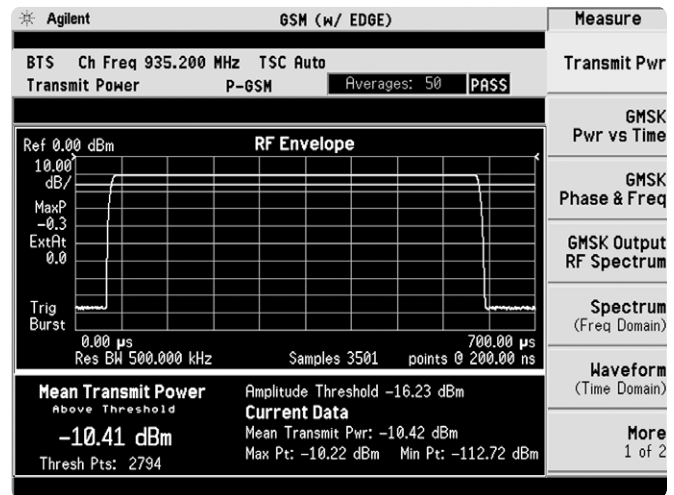
Part 3
GMSK power versus time

GSM is a TDMA multiplexing scheme with eight time slots, or bursts, per frequency channel. If the burst does not occur at exactly the right time, or if the burst is irregular, then adjacent channels can experience interference. Because of this, industry standards specify a tight mask for the fit of the TDMA burst. For easy pass/fail testing the PSA displays the burst for a given time slot on the screen under the mask specified by GSM 05.05 standards.

In this section, measure power versus time for the GSM signal, then view only the rising and falling portions of the burst.

Instructions	Keystrokes
On the PSA:	
Activate power versus time measurement.	[MEASURE] {GMSK Pwr vs Time}
Zoom in on RF envelope (figure 2).	[AMPLITUDE] {Ref Value} [-10] {dBm} {Scale/Div} [0.2] {dB}
View the shape of the rising and falling parts of the burst (figure 3).	[Trace/View] {Rise & Fall}
Expand the rising edge display. You can toggle between the three display sections by pressing the [Next Window] key.	[Next Window] until the upper left part of the display is highlighted in green, [Zoom]
Zoom in on the trace.	[AMPLITUDE] {Ref Value} [-8.5] {dBm} {Scale/Div} [0.5] {dB}
Turn on averaging and display maximum and minimum averaged traces (figure 4). Observe the different types of averaging available under the {Avg Type} menu.	[Meas Setup] {Avg Bursts On} {Avg Type} {Max & Min}
Deactivate averaging and view full display.	{Avg Bursts Off} [Zoom]

Figure 2.
GSM power versus
time measurement
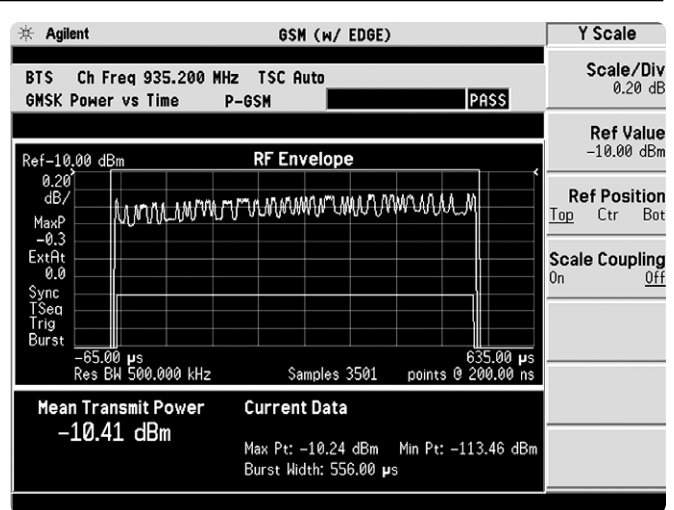
Figure 3.
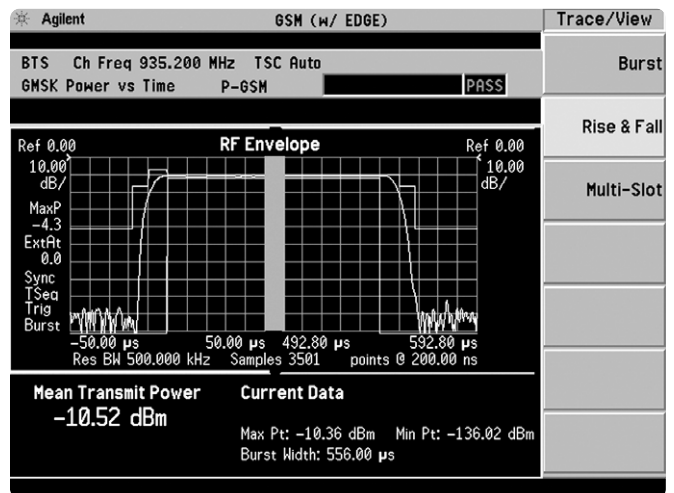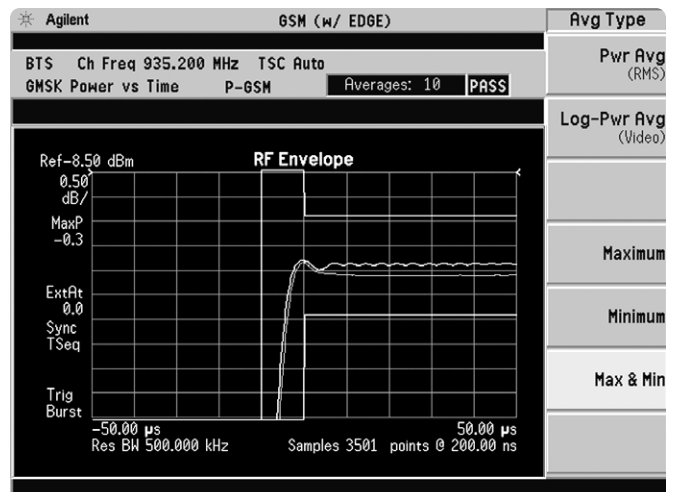**Rising and falling**
edges of GSM burst

Figure 4.
**Rising edge**
with averaging

The PSA is able to measure power versus time for multiple slots at the same time. Multi-slot views give information about the entire GSM frame. This is especially useful for examining slots that transmit at different power levels within a single frame.

Now experiment with the multi-slot capabilities of the PSA.

Instructions	Keystrokes
On the ESG:	
Add another timeslot.	[Mode] {Real Time TDMA} {GSM} {Configure Timeslots} {Timeslot #} [2] {Enter} {Timeslot Type} {Normal All} {Timeslot On}
On the PSA:	
Enable the external trigger.	[Meas Setup] {Trig Source} {Ext Rear}
Switch to multi-slot view in the power versus time measurement.	[Trace/View] {Multi-Slot}
View the entire frame (8 slots) (figure 5).	[Meas Setup] {Meas Time} [8] [Enter]

Figure 5.
Multi-slot power versus time
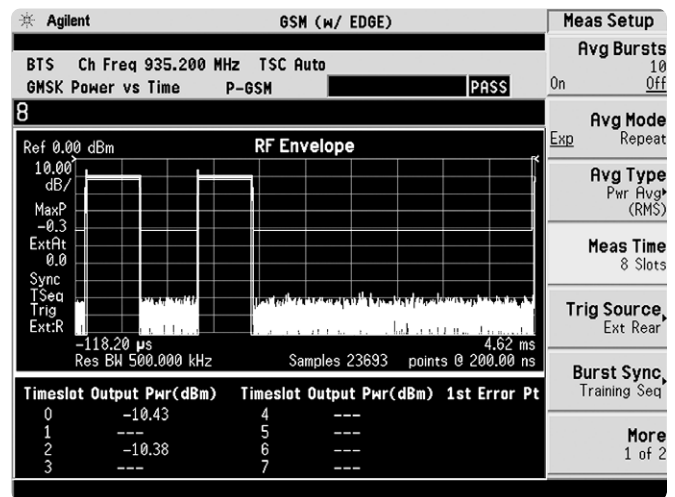
Part 4
GMSK phase and frequency

Phase and frequency error are the measures of modulation quality for GSM systems. Since GSM systems use relative phase to transmit information, phase and frequency accuracy is critical to the system's performance. In a real system, poor phase error will reduce the ability of a receiver to correctly demodulate.

Demodulation and signal analysis required by industry standards is complicated by the challenges of triggering and synchronizing to the actual GSM signal. The Agilent PSA series has multiple trigger and synchronization options to make measurements simple. In this section, a one-button measurement captures the phase and frequency error information.

Instructions	Keystrokes
On the PSA:	
Measure GMSK phase and frequency error.	[MEASURE] {GMSK Phase & Freq}
Enable the external trigger. The two vertical, white bars in the RF Envelope plot in the lower, left part of the display indicate which timeslot is being measured.	[Meas Setup] {Trig Source} {Ext Rear}
Make the measurements on timeslot 2 (figure 6). Notice the bars in the lower, left display move to timeslot 2.	[FREQUENCY] {Timeslot On} [2] {Enter}
View the polar vector diagram (figure 7).	[Trace/View] {I/Q Measured}
View the demodulated I and Q bits (figure 8).	{Data Bits}

**Figure 6.
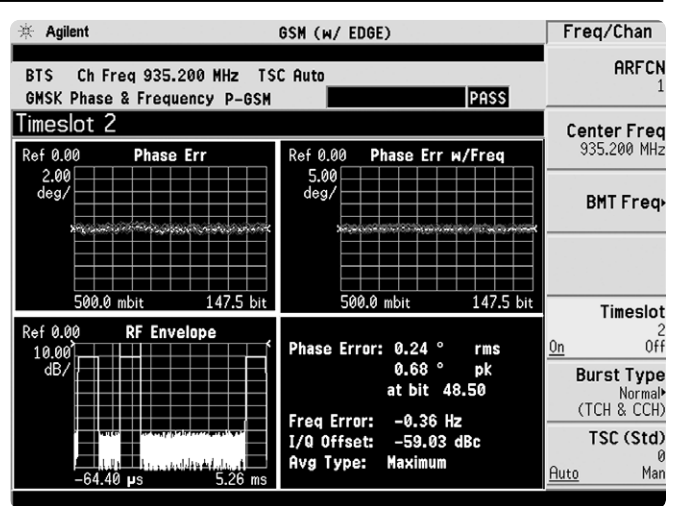Phase and
frequency error**

**Figure 7.
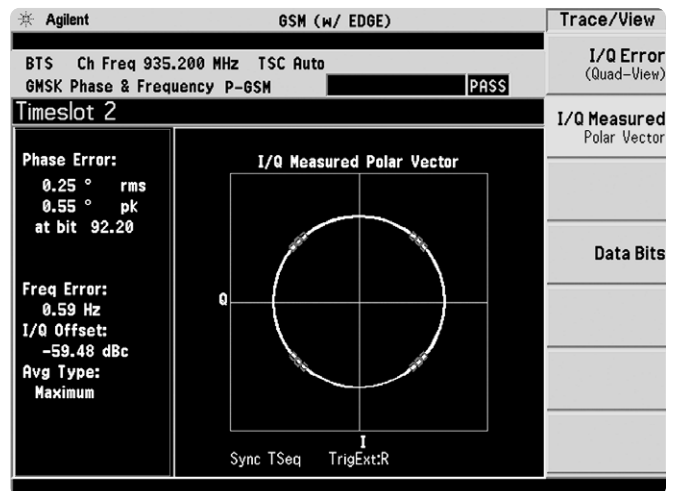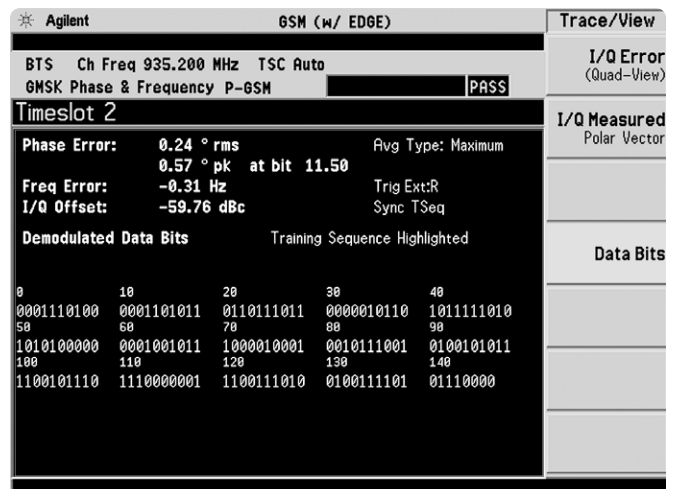I/Q polar vector plot**

**Figure 8.
I and Q
demodulated bits**

Part 5
GMSK output RF spectrum

The modulation process in a transmitter causes the continuous wave (CW) carrier to spread spectrally. This is referred to as "spectrum due to modulation and wideband noise." Defects in the transmit chain may cause the spectrum to spread excessively, resulting in interference with other frequency bands. Measuring the spectrum due to modulation can be thought of as making an adjacent channel power (ACP) measurement where several adjacent channels are considered.

GSM transmitters ramp RF power rapidly. The transmitted RF carrier power versus time measurement is used to ensure that this process happens at the correct times and happens fast enough. However, if RF power is ramped too quickly, undesirable spectral components will arise in the transmitted signal. This upsets the "spectrum due to switching," which again results in interference with other frequency bands.

Spectrum due to modulation and spectrum due to switching measurements are usually grouped together and known as the output RF spectrum (ORFS). The GSM 3GPP (Third-Generation Partnership Project) specifications have particular restrictions on ORFS for a series of frequencies. Verification of compliance with the 3GPP requires up to 80 dB of dynamic range. The PSA series has more than enough dynamic range to accomplish this, and a complete ORFS measurement (modulation and switching) can be performed in 3 seconds*. Another great feature of the PSA's ORFS measurement is its ability to represent the spectrum due to modulation data in either a traditional table format or a spectrum trace with a mask. Both the table and the mask use a pass/fail indicator to signify compliance with the 3GPP specification.

This exercise explores the ORFS measurement using the PSA.

Instructions	Keystrokes
On the ESG:	
Return to a single timeslot signal.	{Timeslot #} [2] {Enter} {Timeslot Off}
On the PSA:	
Set analyzer to make measurements on default timeslot.	[FREQUENCY] {Timeslot Off}
Activate the ORFS measurement (figure 9). The default setting measures spectrum due to modulation at multiple offsets. This measurement takes about one second to complete.	[MEASURE] {GMSK Output RF Spectrum}
Examine spectrum due to modulation at a single offset (250 kHz) (figure 10).	[Meas Setup] {Meas Method} {Single Offset}
Now measure the spectrum due to switching.	{Meas Type} {Switching}
Go back to multi-offset measurement. Observe that this measurement is completed in about 2 seconds.	{Meas Method} {Multi-Offset}
Restore the default measurement.	{More} {Restore Meas Defaults} [Return]
View ORFS with mask (figure 11). This measurement takes several seconds to complete.	{Mod Method Sweep}

* Remote operation with SCPI commands.
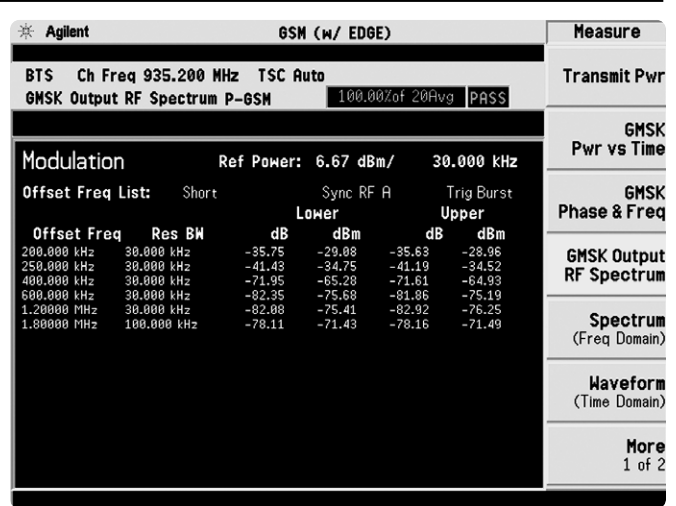
Figure 9.
ORFS spectrum due to modulation

Figure 10.
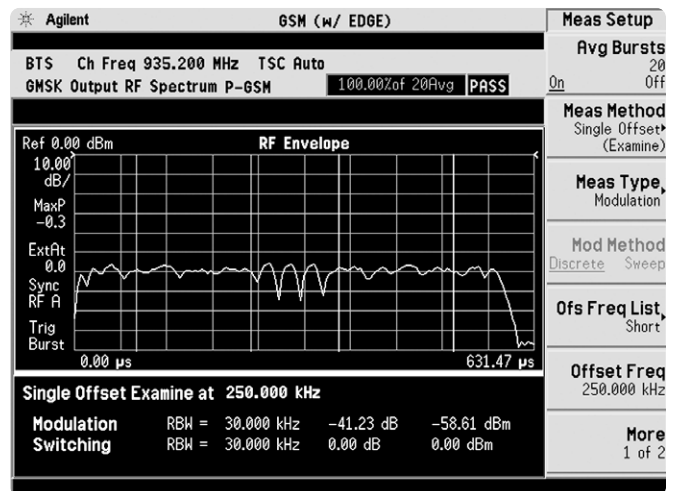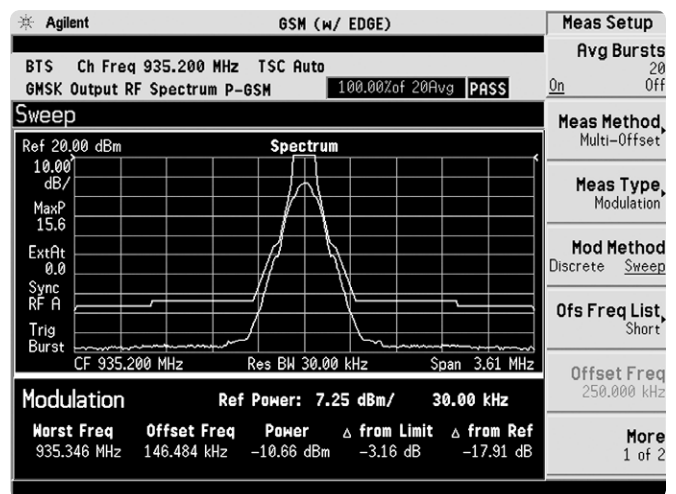**ORFS spectrum due to modulation and switching at 250 kHz**

Figure 11.
ORFS with mask

Part 6
GMSK transmitter band spurious

Transmitter band spurious is a measurement that identifies undesirable energy in wrong parts of the transmitter band. This measurement reveals little more than the switching due to modulation and wideband noise measurement, however, it is a swept measurement with no time gating.

Make this one-button measurement on the PSA. Sufficient power is required at the input for optimum dynamic range, and the PSA will automatically set the attenuation level whenever the measurement is restarted ([Restart] key).

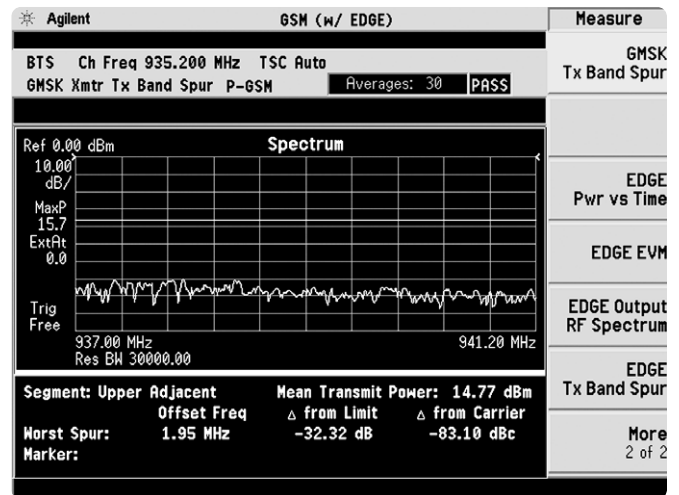| Instructions	Keystrokes
On the ESG:	
Increase the GSM signal amplitude.	[Amplitude] [15] {dBm}
On the PSA:	
Measure transmitter band spurious emissions (figure 12).	[MEASURE] {More} {GMSK Tx Band Spur}

Figure 12.
**GMSK transmitter band spurious**

EDGE has the same spectral characteristics as GSM, as well as the same symbol rate and frame structure (table 1). Therefore, many of the EDGE measurements are almost, if not exactly, identical to the GSM measurements. The only measurement that is significantly different between the two signal formats is modulation accuracy. The critical metric for GSM is phase error. For EDGE, the modulation quality metric is error vector magnitude (EVM).

Figure 13 defines the error vector, a measure of the amplitude and phase differences between the ideal modulated signal and the actual modulated signal. The root-mean-square (rms) of the error vector is computed and expressed as a percentage of the square root of the mean power of the ideal signal. This is the EVM. EVM is a common modulation quality metric widely used in digital communications.

Table 1. Representative specifications for GSM and EDGE signal formats

|	GSM	EDGE
Modulation	GMSK	$3\pi/8$ 8PSK
Bits/symbol	1	3
Data bits per burst	114	342
Symbol rate	270.833 kHz	270.833 kHz
Filter	0.3 Gaussian	Linearized Gaussian

Figure 13.
The error vector
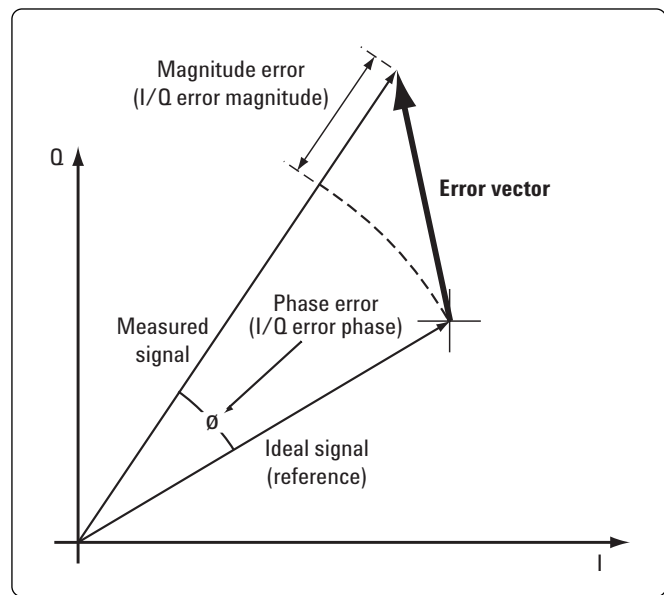
This exercise explores some of the EDGE measurements with emphasis on the EVM measurement.

Instructions	Keystrokes
On the ESG:	
Choose GSM 900 frequency band.	[Preset] [Frequency] {More} {Freq Channels} {Channel Band} {GSM/Edge Bands} {P-GSM Base} {Freq Channels On}
Select EDGE mode and data format.	{Mode} {Real Time TDMA} {EDGE} {Data Format Framed}
Turn on EDGE modulation.	{EDGE On}
Set the amplitude to -10 dBm.	[Amplitude] [-10] {dBm}
Turn on RF output.	[RF On]
On the PSA:	
Make the EDGE power versus time measurement (figure 14). Observe the greater amplitude variations within the burst compared to the GSM signal.	[MEASURE] {More} {EDGE Pwr vs Time}
Measure EDGE ORFS.	[MEASURE] {More} {EDGE Output RF Spectrum}
Activate the EDGE EVM measurement (figure 15).*	[MEASURE] {More} {EDGE EVM}
View error and EVM plots.	[Trace/View] {I/Q Error}
Examine the demodulated data bits (figure 16).	{Data Bits}

**Figure 14.
EDGE power
versus time**
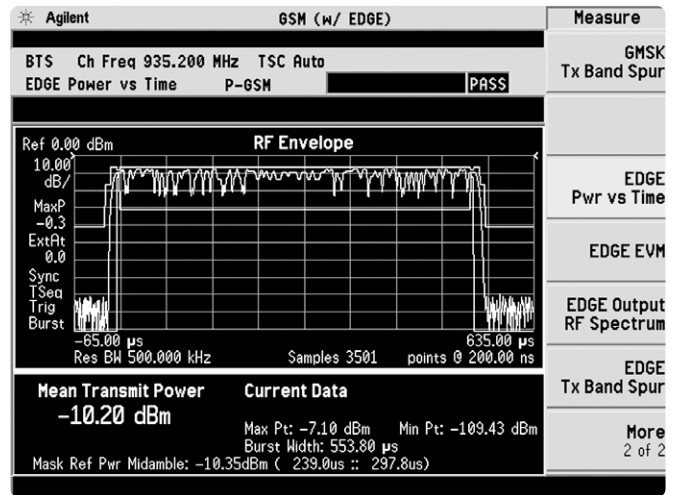
* Though the EDGE signal has considerable inter-symbol-interference (ISI), Agilent's proprietary ISI compensation algorithm provides both a clear constellation diagram and accurate EVM measurements.

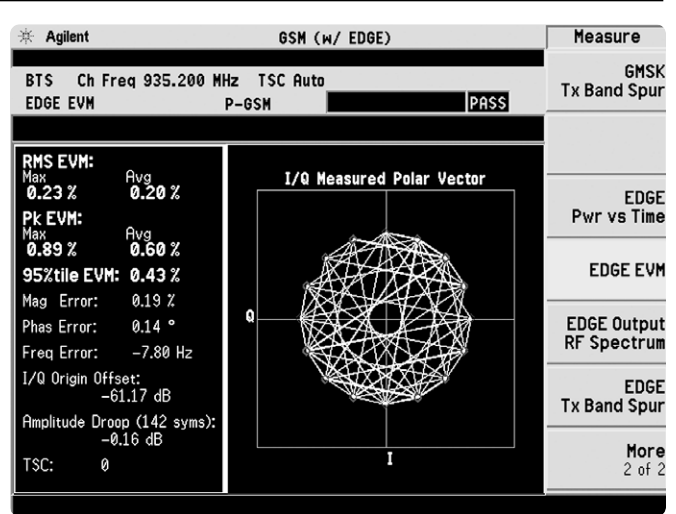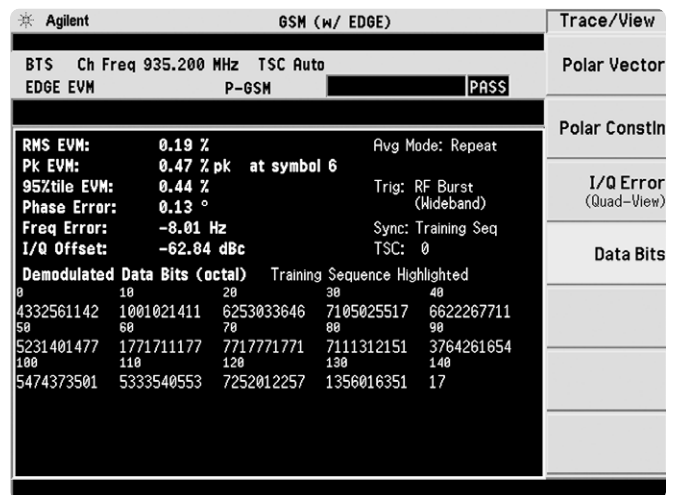**Figure 15.
EDGE EVM
measurement with
polar vector plot**

**Figure 16.
EDGE demodulated
data bits**

Product literature

PSA Series - The Next Generation, brochure, literature number 5980-1283E

PSA Series, data sheet, literature number 5980-1284E

Phase Noise Measurement Personality, product overview, literature number 5988-3698EN

W-CDMA Measurement Personality, product overview, literature number 5988-2388EN

GSM with EDGE Measurement Personality, product overview, literature number 5988-2389EN

cdma2000 Measurement Personality, product overview, literature number 5988-3694EN

1xEV-DO Measurement Personality, product overview, literature number 5988-4828EN

cdmaOne Measurement Personality, product overview, literature number 5988-3695EN

NADC/PDC Measurement Personality, product overview, literature number 5988-3697EN

PSA Series Spectrum Analyzers, Option H70, 70 MHz IF Output, product overview, literature number 5988-5261EN

Self-Guided Demonstration for Spectrum Analysis, product note, literature number 5988-0735EN

Self-Guided Demonstration for Phase Noise Measurements, product note, literature number 5988-3704EN

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Self-Guided Demonstration for GSM and EDGE Measurements, product note, literature number 5988-3700EN

Self-Guided Demonstration for cdma2000 Measurements, product note, literature number 5988-3701EN

Self-Guided Demonstration for 1xEV-DO Measurements, product note, literature number 5988–6208EN

Self-Guided Demonstration for cdmaOne Measurements, product note, literature number 5988-3702EN

Self-Guided Demonstration for NADC and PDC Measurements, product note, literature number 5988-3703EN

PSA Series Demonstration CD, literature number 5988-2390EN

Optimizing Dynamic Range for Distortion Measurements, product note, literature number 5980-3079EN

PSA Series Amplitude Accuracy, product note, literature number 5980-3080EN

PSA Series Swept and FFT Analysis, product note, literature number 5980-3081EN

PSA Series Measurement Innovations and Benefits, product note, literature number 5980-3082EN

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Selecting the Right Signal Analyzer for Your Needs, selection guide, literature number 5968-3413E

8 Hints for Millimeter Wave Spectrum Measurements, application note, literature number 5988–5680EN

PSA Series Spectrum Analyzer Performance Guide Using 89601A Vector Signal Analysis Software, product note, literature number 5988-5015EN

89600 series + PSA, 802.11A and HiperLAN2 ODFM Measurements, product note, literature number 5988-4094EN

N4256A Amplifier Distortion Test Set, product overview, 5988-2925EN

BenchLink Web Remote Control Software, product overview, literature number 5988-2610EN

HP 8566B/68B Programming Code Compatibility for PSA and ESA-E Series Spectrum Analyzers, product overview, literature number 5988-5808EN

IntuiLink Software, Data Sheet, Literature Number 5980-3115EN

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